Manual No. 91000116-001
Revision B
October 15, 2002

The *Mega*Plus®
Model ES 4.0/E Camera
User's Manual

REDLAKE®

Redlake MASD, Inc.
11633 Sorrento Valley Road
San Diego, California 92121-1010

Telephone: 800-854-7006 (USA and Canada only)
Fax: 858-481-6254
Outside the USA: 858-481-8182
Internet: www.redlake.com

List of Manual Revisions

User's Manual – Model ES 4.0/E, Part Number 91000116-001

Revision	Date	EO No.	Notes
A	07-15-02		Initial Issue of ES 4.0/E User's Manual.
B	10-15-02		Inserted corrected dimensional drawings. Inserted additional commands. All changes identified by a vertical bar in the margin.

RELATED DOCUMENTS

*Mega*Plus Model ES 4.0/E Remote Control Panel User's Manual, Part Number 91000117-001

FCC DECLARATION OF CONFORMITY

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Subpart B of Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

This equipment has been certified to comply with the limits for a Class A computing device, pursuant to FCC rules. In order to maintain compliance with FCC regulations, shielded cables must be used with this equipment. Operation with non-approved equipment or unshielded cables is likely to result in interference to radio and TV reception. The user is cautioned that changes and modifications made to the equipment without the approval of the manufacturer could void the user's authority to operate this equipment.

Copyright © 2002 Redlake MASD, Inc.
The information in this manual is for information purposes only and is subject to change without notice. Redlake MASD, Inc. makes no warranty of any kind with regards to the information contained in this manual, including but not limited to implied warranties of merchantability and fitness for a particular purpose. Redlake MASD, Inc. shall not be liable for errors contained herein nor for incidental or consequential damages from the furnishing of this information. No part of this manual may be copied, reproduced, recorded, transmitted or translated without the express written permission of the Redlake MASD, Inc.

PRECAUTIONS

WARNING!

LIFE SUPPORT APPLICATIONS POLICY

***Mega*Plus cameras are not authorized for and should not be used within life support systems without the specific written consent of Redlake MASD, Inc.**

NON-CRITICAL MEDICAL APPLICATIONS

***Mega*Plus cameras must be grounded to building earth ground while operating. This camera has passed IEC 601 class B standards.**

The voltage drop on the camera's power return line must be less than 0.5 Volts DC. Use a heavier gauge power cable to reduce the voltage drop below 0.5 Volts DC. For medical applications, any power supply connected to the camera must meet IEC 601 specifications.

CAUTION: A laser beam focused on the sensor, either directly or by reflection, can cause permanent damage to the sensor. Any laser powerful enough to produce localized heating at the surface of the sensor will cause damage, even if the camera power is off. A sensor damaged by laser light is NOT covered by the warranty.

OPERATING TEMPERATURE

The *Mega*Plus camera is designed to operate satisfactorily in an environment where the ambient temperature is between 0° and 40°C (32° and 104°F), with no water condensation present.

STORAGE TEMPERATURE

Do not store the equipment in an area where the temperature will drop below –25°C (-13°F) or exceed 70°C (158°F). Do not allow moisture to condense on the system.

SHIPPING

When shipping, use a carton that protects the camera from shock and moisture, similar to the carton in which the unit was originally delivered. Do not ship the equipment in a cargo area where the temperature will drop below -25°C (-13°F) or exceed 70°C (158°F).

TABLE OF CONTENTS

1. INTRODUCTION 1-1

1.1 INTRODUCTION 1-1
1.2 HOW TO USE THIS MANUAL 1-1

2. CONTROLS AND CONNECTORS 2-1

2.1 CAMERA 2-1
2.1.1 Mounting the Camera 2-1
2.1.2 Attaching the Lens 2-1
2.2 CAMERA REAR PANEL 2-2
2.2.1 Digital Interface 2-2
2.2.2 Trigger 2-2
2.2.3 Strobe 2-2
2.2.4 DC Power Input 2-2
2.3 CABLES 2-3
2.4 HARDWARE SETUP 2-4
2.5 ROUTINE MAINTENANCE 2-5
2.6 TECHNICAL SUPPORT/CONTACT INFORMATION 2-5

3. CAMERA OPERATION 3-1

3.1 INTRODUCTION 3-1
3.2 SERIAL INTERFACE PROTOCOL 3-1
3.3 ERROR CODES 3-2
3.4 CONTROL COMMANDS 3-2
3.4.1 Readout Channels 3-2
3.4.2 Mode Control 3-2
3.4.3 Continuous 3-2
3.4.4 Continuous Fluoroscopy 3-3
3.4.5 Controlled 3-3
3.4.6 Trigger 3-3
3.4.7 Double Exposure 3-3
3.4.8 Mode 3-4
3.4.9 Binning Selection 3-4
3.4.10 Frame Rate Set 3-4
3.4.11 Exposure 3-5
3.4.12 Trigger 3-5
3.4.13 Transfer Pulse Delay 3-6
3.4.14 Transfer Pulse Width 3-6
3.4.15 Pixel-by-Pixel Corrector 3-7
3.4.16 Digital Gain 3-7
3.4.17 Gain Select 3-7
3.4.18 Look Up Table 3-7
3.4.19 Alternate Correction Table 3-8
3.4.20 Strobe Polarity 3-8
3.4.21 Defect Conceal 3-8
3.4.22 Save 3-8
3.4.23 Reset 3-9
3.4.24 Display Wedge 3-9
3.4.25 Smear Correction 3-9
3.4.26 PSC Command 3-10
3.4.27 Serial Communication Protocol 3-10
3.4.28 Fast Read Mode 3-10
3.5 QUERY COMMANDS 3-11

3.5.1 Temperature Query *3-11*
3.5.2 Status Query *3-11*
3.5.3 Identification Query *3-11*
3.6 ALPHABETICAL COMMAND SUMMARY 3-12

4. INTERFACE SPECIFICATIONS 4-1

4.1 INTRODUCTION 4-1
4.2 DIGITAL INTERFACE CONNECTOR 4-1
4.3 CAMERA LINK CONNECTOR (OPTIONAL) 4-1
4.4 DIGITAL VIDEO OUTPUTS 4-1
4.5 TIMING OUTPUTS 4-1
4.6 CONTROL INPUTS 4-1
4.7 TIMING WAVEFORMS 4-5
4.8 SPECIFICATIONS 4-7
4.8.1 Video Performance *4-7*
4.8.2 Camera Mechanical *4-7*
4.8.3 Temperature *4-7*
4.8.4 Humidity *4-7*
4.9 C-MOUNT CAMERA DIMENSIONS 4-8
4.10 F-MOUNT CAMERA DIMENSIONS 4-10

APPENDIX A – ERROR CODES AND DESCRIPTIONS I

LIST OF FIGURES

Figure 2-1. Camera Body Bottom 2-1
Figure 2-2. C-Mount Lens Length Limit 2-1
Figure 2-3A. Rear Panel (CameraLink) Figure 2-3B. Rear Panel (RS422/LVDS) 2-2
Figure 2-4. DC Power Connector Pins 2-2
Figure 2-5. ES 4.0/E Cable Types 2-3
Figure 2-6. Component Connection Diagram 2-4
Figure 3-1. Wedge Display Patterns 3-9
Figure 4-1. Digital Interface Connector 4-2
Figure 4-2. Continuous Mode – Variable Exposure Timing 4-5
Figure 4-3. Continuous Mode – Variable Exposure Timing (With External Trigger Sync) 4-5
Figure 4-4. Triggered Mode Timing 4-5
Figure 4-6. Double Image Mode Timing 4-6
Figure 4-7. Controlled Mode Timing 4-6
Figure 4-8. Line Timing 4-6
Figure 4-9. C-Mount Camera Dimensions (Front and Bottom Views) 4-8
Figure 4-10. C-Mount Camera Dimensions (Side View) 4-9
Figure 4-11. F-Mount Camera Dimensions (Front and Bottom Views) 4-10
Figure 4-12. F-Mount Camera Dimensions (Side View) 4-11

LIST OF TABLES

Table 4-1. Digital Interface Connector Pin Out (on rear of camera) 4-2
Table 4-2. 68-Pin Interface Cable*, With 9-Pin RS232 Cable 4-3
Table 4-3. 26-Pin Camera Link Cable Pinout 4-4

THIS PAGE INTENTIONALLY LEFT BLANK

1. INTRODUCTION

1.1 Introduction

With spatial resolution of four million pixels, and several different frame rates achieved through binning, the Redlake MASD, Inc. *Mega*Plus Camera, Model ES 4.0/E, is designed for medical, scientific, inspection, and machine vision applications. The compact camera package operates through a digital connection to a host computer. The digital interface connector, located on the camera's rear panel, sends eight-bit digital output video to the computer and receives control commands from the computer. This camera can be ordered with a twelve-bit digital video output and/or a Camera Link interface as options.

Featuring an interline Charge Coupled Device (CCD) sensor array, the camera has 2048 (H) x 2048 (V) light sensitive elements (pixels). These pixels are 7.4 microns square with a 60% fill ratio. This *Mega*Plus camera model has individual gain and offset correction for each pixel. Pixel by pixel gain and offset correction gives the camera a uniform flat field response at all light levels.

The camera operates continuously or in one of three triggered modes. A minimum programmable exposure time of 98 microseconds (98μs) is possible with the camera's electronic shutter. The frame rate is unaffected by the exposure time in continuous mode. The camera is capable of binning and has dual output channels with data rates of 10, 20 or 40 MHz. In the 512 x 512 mode, the camera has a maximum frame rate of 60 fps. In the 1K x 1K binning mode, the camera has a maximum frame rate of 30 fps. In the 2K x 2K binning mode, the camera has a maximum frame rate of 15 fps at 40Mhz and 8 fps at 20Mhz. The camera requires a maximum of 24 watts at 24 volts DC and can be connected to commercially available frame grabber boards capable of handling twelve bits of video data. Please note that some frame grabber boards may not support the highest camera frame rates. Check with your frame grabber board manufacturer.

1.2 How to Use This Manual

WARNINGS, CAUTIONS and NOTES
As you read this manual, you will notice that some of the information is presented as a WARNING, CAUTION or NOTE. It is important that you understand the significance of these terms.

A **WARNING** is important to the safety of anyone operating the Camera and should not be disregarded under any circumstances.

A **CAUTION** is intended to alert you to an operation or condition that may cause loss of data or harm to your Camera.

A **NOTE** contains information that is important to the operation of your Camera.

Chapter 1 contains an explanation of this manual and a warranty statement.

Chapter 2 explains the function of the controls and connectors of the *Mega*Plus Camera.

Chapter 3 contains the commands used to operate the camera. The camera is remotely operated by entering commands into a computer connected to the camera.

Chapter 4 details the signals carried by the digital interface connector, including timing waveforms.

LIMITED WARRANTY

For a period of one (1) year from the date of shipment, the Redlake Product and any Redlake manufactured accessories (collectively the "Product"), shall perform substantially in accordance with the material provisions of the user manual for the Product ("Limited Warranty"). If, because of a defect in workmanship or material, the Redlake Product fails to perform in accordance with the Limited Warranty, then, as the sole available remedy, Redlake shall repair or replace, at Redlake's option, the Redlake Product or any part thereof. The sole remedy of repair and replacement is contingent upon shipment of the Product, within the Limited Warranty period, to Redlake's United States facility. Redlake shall have no obligation under this Limited Warranty to provide local repair or replacement services for the Product, but will, at Redlake's sole discretion, provide repair and replacement service under the terms of the Limited Warranty at its non-United States facilities upon prior written request of the Product Purchaser.

NOTE: THIS WARRANTY DOES NOT APPLY TO THE FOLLOWING CONDITIONS:
(1) damage caused by a failure to operate the Product in accordance with Redlake's written instructions, including, but not limited to, environmental specifications listed in the Redlake user manual; (2) damage caused by accidental user damage, misuse or abuse of the Product; (3) damage caused by the unauthorized attempted repair of or tampering with the Product by non-Redlake personnel; or (4) damage resulting from shipping of the Product.

EXCEPT FOR THE LIMITED WARRANTY STATED IN THIS SECTION, REDLAKE DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO, ANY WARRANTY OF MERCHANTABILITY, NON-INFRINGEMENT, OR FITNESS FOR A PARTICULAR PURPOSE, REGARDING THE REDLAKE PRODUCT OR ANY PART THEREOF.

IN NO EVENT SHALL REDLAKE BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES, INCLUDING WITHOUT LIMITATION LOSS OF BUSINESS OR PROFITS, EVEN IF REDLAKE RECEIVES NOTICE IN ADVANCE THAT THESE KINDS OF DAMAGES MIGHT RESULT, NOR SHALL REDLAKE'S AGGREGATE CUMULATIVE LIABILITY TO THE PRODUCT PURCHASER, PRODUCT RECIPIENT, OR PRODUCT CUSTOMER, PURSUANT TO ANY AND ALL CLAIMS AND LEGAL THEORIES (INCLUDING NEGLIGENCE AND BREACH OF CONTRACT), EXCEED THE ORIGINAL COST OF THE PRODUCT PAID TO REDLAKE BY THE ORIGINAL PURCHASER OF THE PRODUCT.

Redlake MASD, Inc. 11633 Sorrento Valley Road, San Diego, California 92121-1010
(Redlake, *Mega*Plus and 3M are trademarks.)

2. CONTROLS AND CONNECTORS

2.1 Camera

NOTE: A lens cap is installed on each camera to keep dust from getting on the optical sensor or components when it is shipped. Remove the lens cap and install your lens in a dust free environment.

2.1.1 Mounting the Camera

The *Mega*Plus camera has two ¼-20 threaded screw holes for mounting purposes on the bottom of the camera body (see Figure 2-1). There are two secondary holes, 0.23 inches (5.84 mm) in diameter, to accommodate a locating pin. There are complete dimensional drawings at the end of Chapter 4 of this manual.

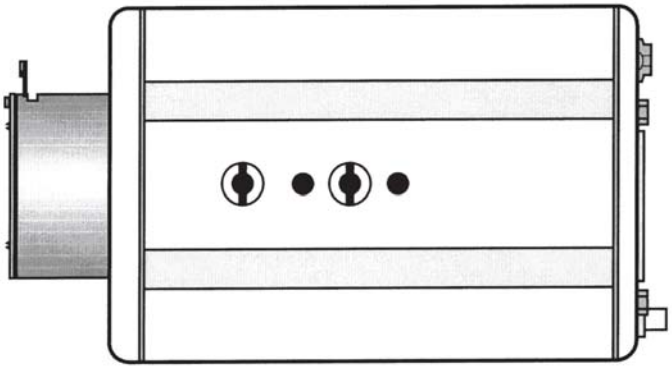

Figure 2-1. Camera Body Bottom

2.1.2 Attaching the Lens

The camera can be purchased with either a C-mount or F-mount lens adapter. If your camera is equipped with an F-mount lens adapter, insert the lens into the locking ring, then rotate the lens counterclockwise until it clicks into position. To remove the lens, hold the release button down as you rotate the lens clockwise.

If your camera is equipped with a C-mount lens adapter, screw the lens clockwise into the adapter until you are no longer able to turn the lens with light pressure.

CAUTION: Some C-mount lenses may extend into the camera more than 0.20 inches (5.08 mm), which may cause damage to internal optical components. Check the dimension of any lens you plan to use as shown in Figure 2-2.

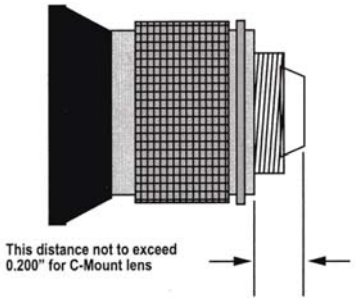

Figure 2-2. C-Mount Lens Length Limit

Figure 2-3A. Rear Panel (CameraLink)

Figure 2-3B. Rear Panel (RS422/LVDS)

2.2 Camera Rear Panel

2.2.1 Digital Interface

The Digital Interface is available as a 68-pin, high density, dual row, D type connector or, as a purchased option, a 26-pin, high-density Camera Link connector that connects the camera to a frame grabber board and a serial communication interface for camera control. The frame grabber board processes and displays video from the camera. A complete technical description of the connectors and the signals that they carry is contained in Chapter 4 of this manual.

2.2.2 Trigger

The TRIGGER coaxial SMA type input connector on the rear panel of the camera accepts CMOS TTL signals with a threshold of approximately 2.5 volts. The trigger pulse should have duration of at least 100 nanoseconds and should be transmitted to the camera using a coaxial cable terminated at the camera. The camera synchronizes to an external event using this input. The operator can set the camera to respond to a positive or negative going trigger signal. See the timing waveforms in Chapter 4 of this manual.

2.2.3 Strobe

The STROBE coaxial SMA type connector on the rear panel of the camera outputs a signal that is TTL compatible and can drive a 50-ohm load. The strobe output pulse should be transmitted through a coaxial cable with a terminating resistor at the receiving end. The leading edge of this output signal can be used to fire a strobe light. The output signal polarity is user-definable. See the timing waveforms in Chapter 4 of this manual.

2.2.4 DC Power Input

The DC power input is a two-pin connector. The power supply voltage must be 24 volts DC, ±4 volts DC, measured at the camera's power connector. The current draw is a maximum of 1.0 amp with a typical draw of 0.8 amps.

WARNING!

Reversing the polarity of the DC voltage input or applying voltage levels in excess of 30 volts may permanently damage the camera. Pin 1 must be positive with respect to the other pin. Pin 1 is nearest the RED DOT on the connector ring. See Figure 2-4.

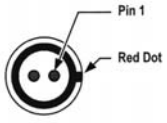

Figure 2-4. DC Power Connector Pins

2.3 Cables

There are three different cables available to connect the *Mega*Plus Camera to your computer, as shown in Figure 2-5 below. The cable needed to connect your camera to your frame grabber depends upon the options you selected at purchase.

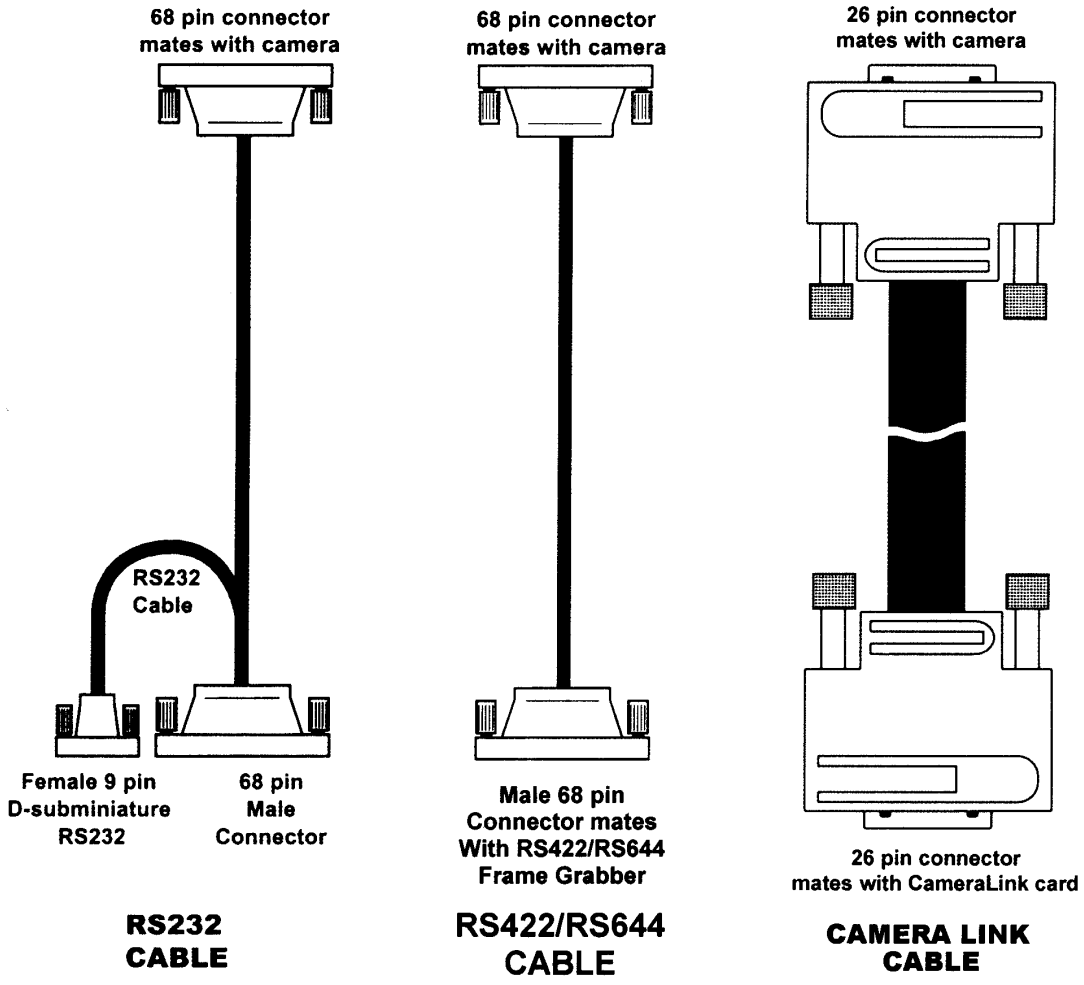
68 pin connector mates with camera
RS232 Cable
Female 9 pin D-subminiature RS232
68 pin Male Connector
RS232 CABLE
68 pin connector mates with camera
Male 68 pin Connector mates With RS422/RS644 Frame Grabber
RS422/RS644 CABLE
26 pin connector mates with camera
26 pin connector mates with CameraLink card
CAMERA LINK CABLE

Figure 2-5. ES 4.0/E Cable Types

2.4 Hardware Setup

Follow the instructions supplied by the frame grabber manufacturer when you are using their cables to install your camera. If using Redlake supplied cables, connect the camera as shown in Figure 2-6 below. Your equipment may vary from that illustrated below.

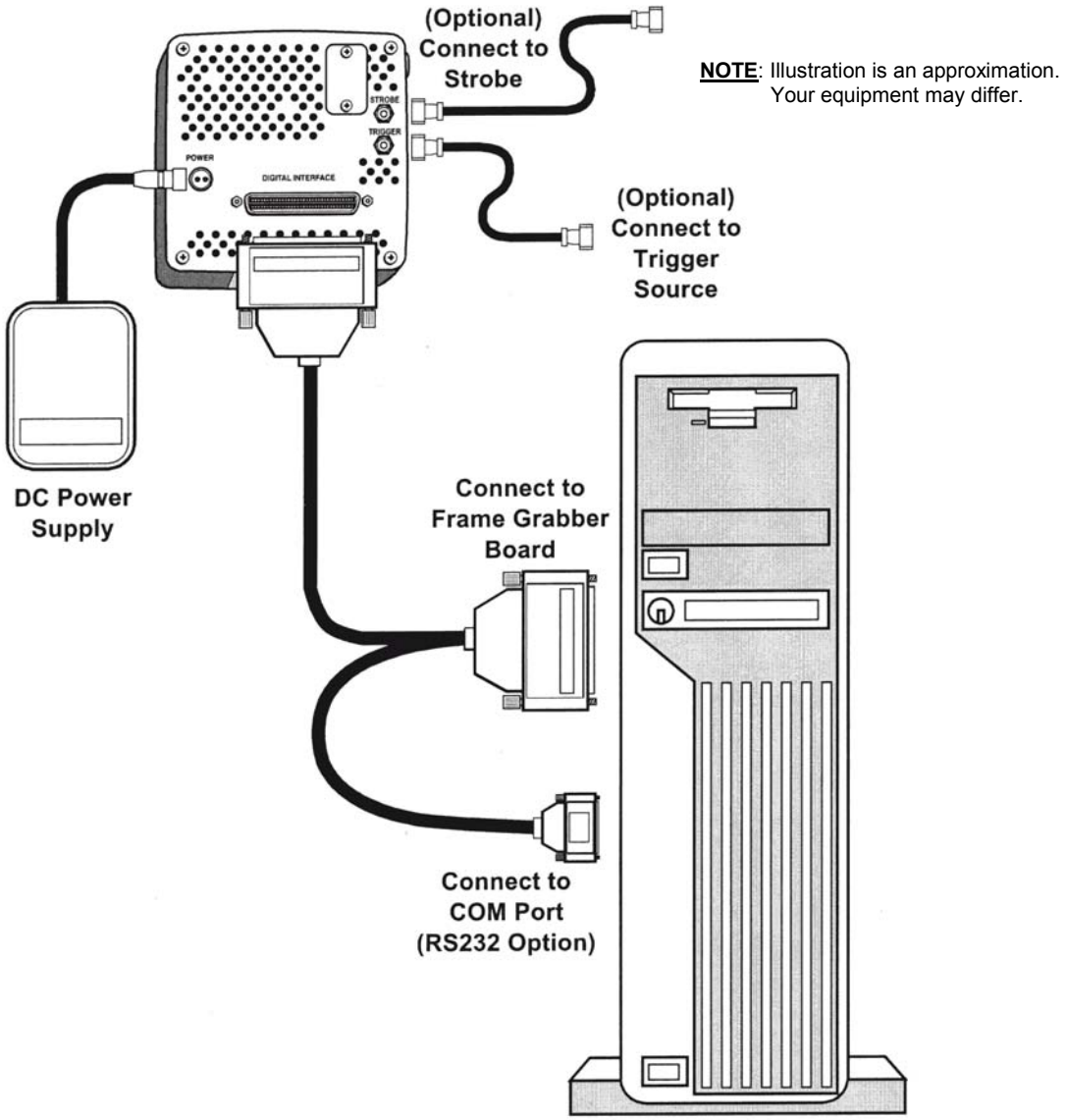

Figure 2-6. Component Connection Diagram

2.5 Routine Maintenance

There are no user serviceable parts inside the camera. The camera must be returned to the factory for repair if a malfunction occurs.

The lens and the sensor cover glass should only be cleaned using dust-free compressed air.

Clean the exterior of the camera with a soft, dry, lint-free cloth. For stubborn dirt, the cloth may be dampened with a mild soap solution.

2.6 Technical Support/Contact Information

FOR TECHNICAL SUPPORT OR OTHER INFORMATION, CONTACT US AT:

Telephone: 1-800-854-7006 (USA and Canada only)
Outside the USA: (858) 481-8182
Fax: (858) 350-9380
Internet: www.redlake.com

Mailing Address:
Redlake MASD, Inc., 11633 Sorrento Valley Road, San Diego, California 92121-1010

For international customers, please contact your authorized Redlake MASD, Inc. Distributor for information. You may also contact one of the below listed service centers:

Roper Scientific BV (Europe, Middle East and Africa):
Telephone: (31) 347 32 4989
Fax: (31) 347 32 4979
Internet: subbink@roperscientific.com

Mailing Address:
Roper Scientific BV, Ir. D.S. Tuijnmanweg 10, 4131 PN Vianen, Nederland

Nippon Roper KK, Japan: (For Japan Only)
Telephone: (81) 3 5639 2770
Fax: (81) 3 5639 2775
Internet: ishiba@roper.co.jp

Mailing Address:
Nippon Roper KK, 6F Sakurai Building, 2 8 19 Fukagawa Koto Ku, Tokyo, 135-0033, Japan

THIS PAGE INTENTIONALLY LEFT BLANK

3. CAMERA OPERATION

3.1 Introduction

The *Mega*Plus camera, Model ES 4.0/E, does not have any manual controls on the camera itself. Camera operation is accomplished by commands sent to the camera through a serial data link from a personal computer (PC). The camera serial data link may be either RS232 or RS422. In either case, the command syntax is the same.

The commands in this chapter are in the order that you would use to setup a camera for the first time. A list of the camera functions, commands and appropriate page numbers follows:

NOTE:	The commands can be entered in either upper or lower case.

NOTE:	These same commands and their argument ranges are alphabetized and summarized on page 3-12.

FUNCTION	COMMAND	PAGE
Readout Channels	RDM	3-2
Mode Command	MDE	3-4
Binning Set	BNS	3-4
Frame Rate Set	FRS	3-5
Exposure	EXE	3-5
Trigger	TRS, TRM, TRE	3-6
Transfer Pulse Delay	TPD	3-6
Transfer Pulse Width	TPW	3-7
Pixel by Pixel Corrector	OGC	3-7
Digital Gain	DGN	3-7
Gain Select	GAS	3-7
Look Up Table	LUT	3-7
Alternate Correction Table	ACT	3-8
Strobe Polarity	STP	3-8
Defect Conceal	DEF	3-8
Save	SAV	3-8
Reset	RST	3-9
Display Wedge	WDG	3-9
Smear Correction	SMC	3-10
Serial Communication	SCP	3-10
PSC Command	PSC	3-10
Fast Read Mode	FAS	3-10
Identification Query	IDN	3-11
Status Query	STS	3-11
Temperature Query	TMP	3-11

3.2 Serial Interface Protocol

The camera uses a full duplex UART type asynchronous system, using standard nonreturn-to-zero (NRZ) format (one start bit, eight data bits, one stop bit, no parity). The baud rate is fixed at 9600. The character code is ASCII standard.

The character flow control protocol is XON/XOFF. XON is assigned DC1 (control-Q) and XOFF is assigned DC3 (control-S). The receiver sends the XOFF character when it wants the sender to pause in sending data and an XON character when it wants the sender to resume.

The camera will recognize a command as three command characters, followed by a space character (or "?" in the case of a query), followed by an argument that consists of one or more characters, ended by the carriage return and line feed characters. The camera responds to a valid command with a carriage return and line feed (CR-LF).

3.3 Error Codes

The camera responds to an erroneous command or query by presenting the user with an error code. The error codes and an explanation for each code are contained in Appendix A of this manual.

3.4 Control Commands

NOTE: This section of the manual contains the commands and arguments in bold type. The carriage return and line feed at the end of each command are not shown, as they are required in every instance.

3.4.1 Readout Channels

Use this command to switch to single channel operation.

Suggestion: Set the camera frame rate to 8 fps (frames per second) using the FRS command before changing the number of readout channels. Otherwise, the camera may change the frame rate. See the valid frame rates versus readout channels listed on page 3.5 within the FRS command description.

TYPE IN:	RESPONSE	EXPLANATION
RDM 1	CR-LF	Sets the camera to single channel readout.
RDM 2	CR-LF	Sets the camera to dual channel readout.
RDM?		Queries the camera's current readout.
	RDM x	Means the readout is set as indicated.

3.4.2 Mode Control

The *Mega*Plus camera operates in one of six modes: continuous, continuous fluoroscopy, controlled, trigger, and double exposure. The mode of operation is selected by the MODE command. The timing waveforms in Chapter Four may help you understand the different modes of operation.

3.4.3 Continuous

The camera will take pictures at 15 fps in 2K x 2K binning mode, 30 fps in 1K x 1K binning mode, and 60 fps in 512 x 512 mode. The camera can be synchronized to an external trigger source through the TRIGGER input on the rear panel of the camera or the EXPOSE input of the digital interface connector.

When multiple cameras are driven from the same trigger source, they will be synchronized to each other within ±100 nanoseconds. The exposure time range is between 91 microseconds and 64.957 milliseconds in 2K x 2K binning mode. The exposure time range is between 92 microseconds and 32.451 microseconds in 1K x 1K binning mode. The exposure time range for the 512 x 512 binning mode is approximately 98 microseconds to 16.2 milliseconds.

3.4.4 Continuous Fluoroscopy

This mode is similar to the Continuous mode, except that the electronic shutter is not used. The exposure time in continuous fluoroscopy mode is equal to the frame rate time. A frame rate of 30 fps means that the exposure time is 33.3 milliseconds. Since the exposure is fixed, the software control of exposure is disabled in this mode.

3.4.5 Controlled

The start and exposure time of each image is controlled by input signals supplied by the user to the EXPOSE input pins in the digital interface connector or the trigger input on the rear panel of the camera. The exposure time is equal to the time the EXPOSE input signal is true. The frame rate is inversely proportional to the exposure plus the readout time. The exposure time is unlimited, but at room temperatures, dark field nonuniformities become noticeable with exposure times greater than 100 milliseconds.

3.4.6 Trigger

Each exposure is started by a signal connected to the EXPOSE input pins of the digital interface connector or the trigger input on the rear panel of the camera. The exposure command sets the exposure time. An exposure starts 17 microseconds (± 100 nanoseconds) after the active edge of the trigger pulse and ends at the exposure time selected by the EXE command. Use the TRM command to select the positive or negative edge of the trigger pulse as the trigger point.

The EXPOSE input sets the start time for each frame of video. The camera will ignore additional EXPOSE signals until it completes the current exposure. The trigger mode of operation is used to capture a single image or a sequence of images.

3.4.7 Double Exposure

The double exposure sequence begins after receiving a trigger input through the digital connector or the TRIGGER connector on the rear panel of the camera. The camera captures the first image in the photo diode array, and then transfers this image to the CCD array. The first image is transferred from the CCD to the internal frame store while the second image is being captured by the photo diode array. The second image is then transferred into the CCD array and from there to the internal frame store's second image buffer.

When operating in Double Exposure mode, the maximum frame rate is approximately 11.4 fps due to the necessity for 2 frames per trigger. The camera will ignore triggers that it cannot accept; so more than 5.7 triggers per second will result in slower operation. If the trigger rate is set lower, the camera will track the trigger rate exactly.

3.4.8 Mode

Use this command to set the camera mode of operation.

TYPE IN:	RESPONSE	EXPLANATION
MDE CS	CR-LF	Sets the mode to continuous.
MDE CD	CR-LF	Sets the mode to controlled.
MDE TR	CR-LF	Sets the mode to trigger.
MDE DE	CR-LF	Sets the mode to double exposure.
MDE CF	CR-LF	Sets the mode to continuous fluoroscopy.
MDE?		Queries the current mode setting.
	MDE xx	Means the mode is set as indicated.

3.4.9 Binning Selection

Binning gives you the option of trading resolution for increased frame rate and better signal to noise ratio. Binning is the process of grouping adjacent pixels electronically; thereby reducing the time required to readout an image. This camera can group two adjacent pixels horizontally and vertically giving one quarter the resolution but twice the frame rate with a better signal to noise ratio.

TYPE IN:	RESPONSE	EXPLANATION
BNS 1	CR-LF	No binning is performed; resolution is 2K x 2K pixels.
BNS 2	CR-LF	2 horizontal and 2 vertical pixels are binned together producing an effective resolution of 1K x 1K pixels.
BNS 3	CR-LF	4 horizontal and 4 vertical pixels are binned together producing an effective resolution of 512 x 512 pixels.
BNS?		Queries the current binning selection.
	BNS x	Means the binning selection is set as indicated.

NOTE: Check the camera's frame rate setting after changing the binning setting. Changing the binning setting may cause the frame rate to change to the nearest valid setting.

3.4.10 Frame Rate Set

This command sets the camera's frame rate dimensioned in frames per second (fps). Some frame rates are only valid in specific combinations of readout channels, selected with the RDM command, and binning modes, selected with the BNS command.

If you change the binning mode the camera will switch to the nearest valid frame rate.

NOTE: The FRS command sets the maximum frame rate limit in controlled and continuous modes. FRS must be set to 15 in double exposure mode.

TYPE IN	RESPONSE	RDM=2 BNS=3	RDM=2 BNS=2	RDM=2 BNS=1	RDM=1 BNS=3	RDM=1 BNS=2	RDM=1 BNS=1
FRS 60	CR-LF	60 fps/ 20 MHz	**	**	**	**	**
FRS 30	CR-LF	30 fps/ 20 MHz	30 fps/ 20 MHz	**	30 fps/ 20 MHz	**	**
FRS 15	CR-LF	15 fps/ 10 MHz	15 fps/ 20 MHz	15 fps/ 40 MHz	15 fps/ 20 MHz	15 fps/ 20 MHz	**
FRS 8	CR-LF	**	8 fps/ 10 MHz	8 fps/ 20 MHz	**	8 fps/ 20 MHz	8 fps/ 40 MHz
FRS 4	CR-LF	**	**	4 fps/ 10 MHz	**	**	4 fps/ 20 MHz

3.4.11 Exposure

This command sets the camera exposure time in increments of 0.063 milliseconds. In continuous mode, the camera accepts exposure values from .091 to 64.957 milliseconds when BNS is set to 1; and values between .092 and 32.451 milliseconds when BNS is set to 2. If the camera is operating in triggered mode, the maximum exposure time becomes 112.298 milliseconds.

NOTE: The camera accepts and remembers a different exposure time for each of the three binning modes. The camera switches to the stored exposure time when switching binning modes.

TYPE IN:	RESPONSE	EXPLANATION
EXE xxxx	CR-LF	The argument range is from .091 to 112 to 298 milliseconds in increments of .063 milliseconds, depending on the operating mode, the camera will round up to the next valid setting for any exposure value entered.
EXE?		Queries the current exposure setting. The value returned is the corrected value in milliseconds.
	EXE xxxx	Means the exposure is set, expressed in milliseconds.

NOTE: After EXExxxx or EXE? Has been executed, type in "+" to increase the exposure time or type in "-" to decrease the exposure time by 0.063 milliseconds. The camera will respond with the new value.

3.4.12 Trigger

This command selects the trigger source and polarity. There is two trigger inputs: the SMA connector on the rear panel of the camera (labeled TRIGGER), and the EXPOSE input carried by the digital interface connector. The camera will only respond to the selected source.

TYPE IN:	RESPONSE	EXPLANATION
TRS AIA	CR-LF	Selects the digital interface connector EXPOSE signal as the trigger source.
TRS EXT	CR-LF	Selects the TRIGGER connector on the rear panel as the trigger source.
TRS SW	CR-LF	Selects the TRE software commands as the trigger source.
TRS?		Queries the trigger source.

TRM P (see *NOTE)	CR-LF	A positive going edge at the AIA EXPOSE input trigger connector will start an exposure.
TRM N (See *NOTE)	CR-LF	A negative going edge at the AIA EXPOSE input or the trigger connector will start an exposure.
TRM?		Queries the current EXPOSE polarity.
TRE 0	CR-LF	Ends an exposure in controlled mode if TRS SW is in effect.
TRE 1	CR-LF	Starts an exposure in all modes if TRS SW is in effect.
TRE?		Queries current state of trigger command.

*__NOTE__: The commands TRM and TRP are interchangeable. TRP may be used in place of TRM.

3.4.13 Transfer Pulse Delay

This command only applies to the double exposure mode. Transfer pulse delay sets the exposure time for the first image. The exposure time for the second image is 64.946 milliseconds in 2K x 2K mode, and 32.495 milliseconds with binning set to 1K x 1K.

TYPE IN:	RESPONSE	EXPLANATION
TPD xxx	CR-LF	Sets the delay in increments of 0.2 microseconds. The argument range is from 1 to 999 microseconds. If TPD is set to zero, the EXE value controls the first image exposure time permitting equal exposure time for both images.
TPD?		Queries the current transfer pulse delay time setting.
	TPD xxx	Means the time is set as indicated.

NOTE: After TPD xxx or TPD? has been executed, type in "+" to increase the transfer pulse delay time or type in "-" to decrease the delay time. The camera will respond with the new value.

Sample commands with arguments:

TPD 1.6 Sets the delay time to 1.6 microseconds.
TPD 0 The EXE value now sets the delay time.
TPD 999 Sets the delay time to 999 microseconds.

3.4.14 Transfer Pulse Width

The transfer pulse width is fixed at twelve microseconds, except in double exposure mode. This command sets the duration of the transfer pulse when the camera is in double exposure mode. The transfer pulse width is the time that the first image has to transfer from the photo diode array to the CCD array. As the transfer pulse width becomes shorter, the charge transfer between the arrays does not have time to be completed and image quality will suffer.

TYPE IN:	RESPONSE	EXPLANATION
TPW xx	CR-LF	Sets the delay in increments of one microsecond. The argument range is from 1 to 10 microseconds. The default value is 8.
TPW?		Queries the current transfer pulse width setting.
	TPW xx	Means the pulse width is set as indicated.

3.4.15 Pixel-by-Pixel Corrector

The camera has offset and gain coefficients stored for every active pixel in the sensor. When enabled, this function minimizes pixel-to-pixel offset and gain variations.

TYPE IN:	RESPONSE	EXPLANATION
OGC ON	CR-LF	Turns the offset and gain coefficients on.
OGC OF	CR-LF	Turns the offset and gain coefficients off.
OGC?		Queries the current setting.

3.4.16 Digital Gain

Sets the camera gain to a factor of 1, 2, 4, 8, or 16. In twelve-bit cameras, only DGN 1 or DGN 2 is available.

TYPE IN:	RESPONSE	EXPLANATION
DGN 1	CR-LF	Sets the camera gain to unity.
DGN 2	CR-LF	Sets the camera gain to times 2.
DGN 4	CR-LF	Sets the camera gain to times 4.
DGN 8	CR-LF	Sets the camera gain to times 8.
DGN 16	CR-LF	Sets the camera gain to times 16.
DGN?		Queries the current gain setting.
	DGN x	Indicates the gain is set to x.

3.4.17 Gain Select

This command sets the gain mode selection. See ACT command for additional information.

TYPE IN:	RESPONSE	EXPLANATION
GAS x	CR-LF	Sets the gain selection with an argument range of 0 to 3.
GAS?		Queries the current setting.
	GAS x	Indicates the gain setting is x.

3.4.18 Look Up Table

This command allows the user to turn ON or turn OFF the Look Up Table. The default is ON, and should remain ON unless debugging or another unforeseen application requires the LUT to be turned off.

TYPE IN:	RESPONSE	EXPLANATION
LUT ON	CR-LF	Turns the look up table on.
LUT OF	CR-LF	Turns the look up table off.
LUT?		Queries the current setting.
	LUT xx	Indicates the look up table setting.

3.4.19 Alternate Correction Table

This command allows the user to select either the standard or the alternate Offset and Gain Correction tables. The standard tables are for your default optical configuration (e.g. f/1.4), and the alternate table is for an optional second optical configuration (e.g. f/5.6).

TYPE IN:	RESPONSE	EXPLANATION
ACT 0	CR-LF	Selects the standard OGC Table.
ACT 1	CR-LF	Selects the alternate OGC Table.
ACT?		Queries the current setting.
	ACT x	Indicates the alternate table setting.

3.4.20 Strobe Polarity

The strobe output on the rear panel of the camera provides a trigger pulse for the user. The polarity of the strobe signal is set by this command. The strobe output can drive a 50-ohm load and has a pulse width of 5 microseconds. In double exposure mode only, the strobe output has a pulse width of 800 nanoseconds.

TYPE IN:	RESPONSE	EXPLANATION
STP P	CR-LF	Sets the polarity of the strobe output pulse to positive.
STP N	CR-LF	Sets the polarity of the strobe output pulse to negative.
STP?		Queries the strobe output pulse polarity.

3.4.21 Defect Conceal

Sensors are not perfect and have some pixels that react differently to light. These imperfect pixels are sometimes different in intensity from their neighbors. It is possible to characterize a sensor identifying the abnormal pixels and then to program their locations into the camera at the factory. When defect concealment is turned on, the camera replaces the variant pixels with information derived from nearby pixels, making the nonuniformity disappear.

TYPE IN:	RESPONSE	EXPLANATION
DEF ON	CR-LF	Enables defect concealment.
DEF OF	CR-LF	Disables defect concealment.
DEF?		Queries the state of defect concealment.

3.4.22 Save

At start up, the camera always recalls Save 0. By entering SAV 3, for example, the current settings will be saved to setup 3, and can be recalled by entering RST 3.

TYPE IN:	RESPONSE	EXPLANATION
SAV	CR-LF	Saves the current camera settings to the camera's internal memory. The user can now save up to 10 different operating states. The argument range is from 0 to 9. These settings will be recalled by use of the RST x command, where x is the operating state previously saved.

NOTE: The Flash memory used by the SAVE command has a finite life of roughly 10,000 erase and program cycles. Use this function as needed, but be aware of the flash memory life cycle.

3.4.23 Reset

This command allows you to recall saved (SAV) settings. RST 3, for example, recalls the settings saved when you entered SAV 3.

TYPE IN:	RESPONSE	EXPLANATION
RST	CR-LF	Resets the camera to the settings as last saved in the SAV command. Up to 10 operating states can be recalled by inputting RST x, where x is the operating state previously saved (0 – 9).

3.4.24 Display Wedge

The wedge command displays linearly increasing gray scales in each quadrant of the image as shown in Figure 3-1. The wedge display is not perfectly linear. It contains OGC, DEF and LUT values. The OGC and DEF values can be turned off by the user, but the LUT values cannot be eliminated from the wedge display. In Pattern 1, the pixel value increments every pixel. In Pattern 2, the pixel value increments every line. In Pattern 3, the pixel value increments every frame. The display wedge defaults to OFF when the power to the camera is turned off.

TYPE IN:	RESPONSE	EXPLANATION
WDG ON	CR-LF	Means the wedge is being displayed.
WDG OF	CR-LF	Means the camera is imaging.
WDG 0-3	WDG x	Selects one of the following: 0 = OF 1 = Pattern 1 ON 2 = Pattern 2 ON 3 = Pattern 3 ON
WDG?		Queries the state of the wedge display.

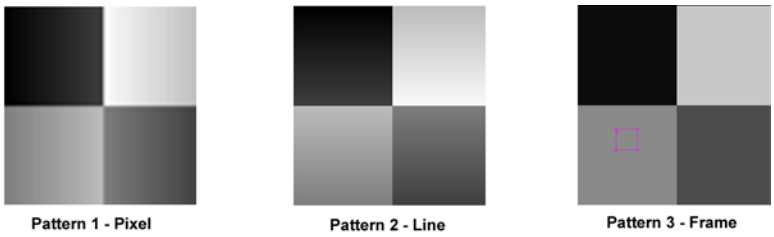

Figure 3-1. Wedge Display Patterns

3.4.25 Smear Correction

This command enables or disables the smear correction feature of the camera. With this feature enabled, the smear content of an image is calculated and then subtracted out of the image.

TYPE IN:	RESPONSE	EXPLANATION
SMC ON	CR-LF	Enables the smear correction feature.
SMC OF	CR-LF	Disables the smear correction feature.
SMC?		Queries the current smear correction setting.
	SMC xx	Smear correction feature is set as indicated.

3.4.26 PSC Command

This command enables or disables the continuous background checks on the fan, Thermoelectric Cooling (TEC), and temperature.

TYPE IN:	RESPONSE	EXPLANATION
PSC ON	CR-LF	Enables the background checks for fan, TEC, and temperature feature.
PSC OF	CR-LF	Disables the background checks for fan, TEC, and temperature feature.
PSC?		Queries the current setting.
	PSC xx	Background check feature is set as indicated.

3.4.27 Serial Communication Protocol

This command allows hardware autodetection override. The command will not be saved in your settings, and the camera will always power up with autodetection enabled.

TYPE IN:	RESPONSE	EXPLANATION
SCP 232	CR-LF	Indicates selection of RS232 protocol.
SCP 422	CR-LF	Indicates selection of RS422 protocol.
SCP?		Queries the current setting.
	SCP xxx	Indicates communications protocol selected.

3.4.28 Fast Read Mode

The command allows the user to reduce the read out time delay from one frame (67 milliseconds) to one line (63 microseconds). The user needs to ensure that their frame grabber board is programmed to re-order the image, as the image will be received from the top and bottom and will move toward the center.

TYPE IN:	RESPONSE	EXPLANATION
FAS ON	CR-LF	Enables the Fast Read mode.
FAS OF	CR-LF	Disables the Fast Read mode.
	FAS xx	Indicates Fast Read mode set as shown.

3.5 Query Commands

3.5.1 Temperature Query

This command queries the temperature sensor on the Processor Board.

TYPE IN:	RESPONSE	EXPLANATION
TMP?		Queries the temperature sensor on the Processor Board. Response is in degrees C.
	xxC	Indicates the camera temperature is as indicated.

3.5.2 Status Query

The status query command enables the user to get all of the camera's operating parameter information with a single command.

TYPE IN:	RESPONSE	EXPLANATION
STS?		Gives complete camera status with one query. The list below shows a typical camera response to this query. Your camera's response may differ, depending upon the password table loaded into your camera.

RESPONSE	DEFINITION	EXAMPLE
BNS x	Shows binning mode.	BNS 1
DEF xx	Shows defect concealment state.	DEF ON
DGN x	Shows the digital gain setting.	DGN 1
EXE xx	Shows the exposure time.	EXE 58
FRS xx	Shows the frame rate setting.	FRS 15
MDE xx	Shows the operating mode.	MDE CS
OGC xx	Shows the offset and gain state.	OGC ON
RDM x	Shows the readout mode.	RDM 2
SMC xx	Shows the smear correction status.	SMC OF
STP x	Shows the strobe pulse polarity.	STP N
TPD xxxx	Shows the transfer pulse delay.	TPD 150.0
TPW xx	Shows the transfer pulse width.	TPW 12
TRM x	Shows the trigger logic polarity. (May use TRP.)	TRM P
TRS xxx	Shows the trigger source setting.	TRS AIA

3.5.3 Identification Query

This command queries the camera for its model number.

TYPE IN:	RESPONSE	EXPLANATION
IDN?		
	MEGAPLUS Camera, Model ES 4.0/E	

3.6 Alphabetical Command Summary

NOTE:	The commands listed below can be entered in either upper or lower case.

FUNCTION	COMMAND	ARGUMENT RANGE	PAGE
Alternate Correction Table	ACT	0, 1	3-8
Binning Set	BNS	1 (2K), 2 (1K), 3 (512)	3-4
Defect Conceal	DEF	on, of	3-8
Digital Gain	DGN	1, 2, 4,	3-7
Display Wedge	WDG	on, of, 0, 1, 2, 3	3-9
Exposure (Triggered)	EXE	.091 to 112.298; increment=0.063mS	3-5
Exposure (2Kx2K)	EXE	.091 to 64.956; increment=0.063mS	3-5
Exposure (1Kx1K)	EXE	.092 to 32.495; increment=0.063mS	3-5
Exposure (512x512)	EXE	.097 to 16.6135; increment=0.058mS	3-5
Fast Read Mode	FAS	on, of	3-10
Frame Rate Set	FRS	4, 8, 15, 30, and 60 (used with Remote Control Panel software)	3-5
Gain Select	GAS	0, 1, 2, 3	3-7
Identification Query	IDN?	(no argument required)	3-11
Look Up Table	LUT	on, of	3-7
Mode Command	MDE	CS, CD, TR, DE, CF	3-4
Offset and Gain Coefficient	OGC	on, of	3-7
PSC Command	PSC	on, of	3-10
Readout Channels	RDM	1, 2	3-2
Reset	RST	0 to 9	3-9
Save	SAV	0 to 9	3-8
Serial Communication	SCP	232, 422	3-10
Smear Correction	SMC	on, of	3-10
Strobe Polarity	STP	p, n	3-8
Status Query	STS?	(no argument required)	3-11
Temperature Query	TMP?	(no argument required)	3-11
Transfer Pulse Delay	TPD	1 to 999; increment=0.2µs	3-6
Transfer Pulse Width	TPW	1 to 10 (MDE=DE)	3-7
Transfer Pulse Width	TPW	12 (MDE=CS, CD, or TR)	3-7
Trigger Expose	TRE	0, 1	3-6
Trigger Polarity	TRM	p, n (May use TRP for same command)	3-6
Trigger Source	TRS	AIA, EXT, SW	3-6

4. INTERFACE SPECIFICATIONS

4.1 Introduction

Chapter Four gives you the information needed to interface the *Mega*Plus Camera, Model ES 4.0/E, to a frame grabber device. The *Mega*Plus camera is a megaresolution black and white camera with eight or twelve bit digital video output. Each frame has 2,048 columns and 2,048 rows of pixels (picture elements) containing valid video data.

4.2 Digital Interface Connector

All of the signals referred to in this section are present at the digital interface connector on the rear panel of the camera. Table 4-1 lists each signal and its pin number. The connector for this port is a 68-pin, high density, dual row, D type connector. This connector is the same as that used for the "SCSI-2 B cable" interface. The connector has 0.050 inch (1.27 mm) pin spacing and a D-type shell that is 2.5 inches (63.5 mm) long.

4.3 Camera Link Connector (Optional)

All of the signals referred to in this section are present at the Camera Link connector on the rear panel of the camera. Table 4-3 lists each signal and its pin number. The connector for this port is a 26-pin, high-density, Mini-D ribbon connector (manufactured by 3M). Cable assemblies and boardmount receptacles are available from Redlake or 3M. For more information on 3M products, see the 3M website at www.3M.com.

4.4 Digital Video Outputs

The camera has provisions for two twelve-bit digital video output channels. Channel A bits are labeled AMSB through AMSB-11. Channel B bits are labeled BMSB through BMSB-11. The AMSB indicates the Most Significant Bit (MSB) and the AMSB-11 is the Least Significant Bit (LSB). These signals are output as differential pairs with signal levels conforming to the RS644 specification. Most RS422 receivers work with RS644 low voltage differential signal levels. The non-inverting part of the differential pair is present on the (+) output, while the inverting pair of the differential pair is present on the (-) output. A signal is true when the (+) line is more positive than the (-) line.

4.5 Timing Outputs

There are three timing outputs presented on the digital interface connector. They are FRME ENA (frame enable), LINE ENA (line enable) and PIX DATA STRB (pixel data strobe). These signals are output as differential pairs with signal levels conforming to the RS644 specification. Most RS422 receivers work with RS644 low voltage differential signal levels. The non-inverting part of the differential pair is present on the (+) output, while the inverting pair of the differential pair is present on the (-) output. A signal is true when the (+) line is more positive than the (-) line.

4.6 Control Inputs

The control input EXPOSE is provided as a means of externally synchronizing the camera. Drive this input differentially by connecting the (+) and (-) inputs to an RS644 driver.

Table 4-1. Digital Interface Connector Pin Out (on rear of camera)

PIN	SIGNAL NAME	PIN	SIGNAL NAME	SOURCE
1	GROUND	35	GROUND	Both
2	AMSB (+)	36	AMSB (-)	Camera
3	AMSB-1 (+)	37	AMSB-1 (-)	Camera
4	AMSB-2 (+)	38	AMSB-2 (-)	Camera
5	AMSB-3 (+)	39	AMSB-3 (-)	Camera
6	AMSB-4 (+)	40	AMSB-4 (-)	Camera
7	AMSB-5 (+)	41	AMSB-5 (-)	Camera
8	AMSB-6 (+)	42	AMSB-6 (-)	Camera
9	AMSB-7 (+)	43	AMSB-7 (-)	Camera
10	BMSB (+)	44	BMSB (-)	Camera
11	BMSB-1 (+)	45	BMSB-1 (-)	Camera
12	TRIGGER	46	TRIGGER	Camera
13	BMSB-2 (+)	47	BMSB-2 (-)	Camera
14	BMSB-3 (+)	48	BMSB-3 (-)	Camera
15	BMSB-4 (+)	49	BMSB-4 (-)	Camera
16	BMSB-5 (+)	50	BMSB-5 (-)	Camera
17	AMSB-10 (+)	51	AMSB-10 (-)	Camera
18	AMSB-11 (+)	52	AMSB-11 (-)	Camera
19	BMSB-6 (+)	53	BMSB-6 (-)	Camera
20	BMSB-7 (+)	54	BMSB-7 (-)	Camera
21	AMSB-8 (+)	55	AMSB-8 (-)	Camera
22	SER CNTRL OUT(+)	56	SER CNTRL OUT(-)	Camera
23	SER CNTRL IN(+)	57	SER CNTRL IN(-)	Processor
24	BMSB-11 (+)	58	BMSB-11 (-)	Camera
25	FRAME DATA VALID(+)	59	FRAME DATA VALID(-)	Camera
26	LINE DATA VALID(+)	60	LINE DATA VALID(-)	Camera
27	BMSB-10 (+)	61	BMSB-10 (-)	Camera
28	BLOOMFLAG (+)	62	BLOOMFLAG (-)	Camera
29	PIXEL CLOCK(+)	63	PIXEL CLOCK(-)	Camera
30	EXPOSE(+)	64	EXPOSE(-)	Host
31	AMSB-9 (+)	65	AMSB-9 (-)	Camera
32	BMSB-8 (+)	66	BMSB-8 (-)	Camera
33	BMSB-9 (+)	67	BMSB-9 (-)	Camera
34	GROUND	68	GROUND	Both

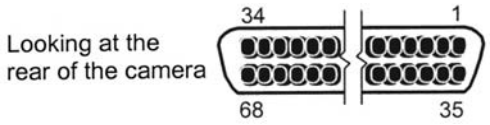

Figure 4-1. Digital Interface Connector

Table 4-2. 68-Pin Interface Cable*, With 9-Pin RS232 Cable

PIN	SIGNAL NAME	PIN	SIGNAL NAME	SOURCE
1	GROUND	35	GROUND	Both
2	AMSB (+)	36	AMSB (-)	Camera
3	AMSB-1 (+)	37	AMSB-1 (-)	Camera
4	AMSB-2 (+)	38	AMSB-2 (-)	Camera
5	AMSB-3 (+)	39	AMSB-3 (-)	Camera
6	AMSB-4 (+)	40	AMSB-4 (-)	Camera
7	AMSB-5 (+)	41	AMSB-5 (-)	Camera
8	AMSB-6 (+)	42	AMSB-6 (-)	Camera
9	AMSB-7 (+)	43	AMSB-7 (-)	Camera
10	BMSB (+)	44	BMSB (-)	Camera
11	BMSB-1 (+)	45	BMSB-1 (-)	Camera
12	GROUND	46	GROUND	Both
13	BMSB-2 (+)	47	BMSB-2 (-)	Camera
14	BMSB-3 (+)	48	BMSB-3 (-)	Camera
15	BMSB-4 (+)	49	BMSB-4 (-)	Camera
16	BMSB-5 (+)	50	BMSB-5 (-)	Camera
17	AMSB-10 (+)	51	AMSB-10 (-)	Camera
18	AMSB-11 (+)	52	AMSB-11 (-)	Camera
19	BMSB-6 (+)	53	BMSB-6 (-)	Camera
20	BMSB-7 (+)	54	BMSB-7 (-)	Camera
21	AMSB-8 (+)	55	AMSB-8 (-)	Camera
22	SER CNTRL OUT(+)	56	SER CNTRL OUT(-)	Camera
23	SER CNTRL IN(+)	57	SER CNTRL IN(-)	User
24	BMSB-11 (+)	58	BMSB-11 (-)	Camera
25	FRME ENA(+)	59	FRME ENA(-)	Camera
26	LINE ENA(+)	60	LINE ENA(-)	Camera
27	BMSB-10 (+)	61	BMSB-10 (-)	Camera
28	Reserved	62	Reserved	
29	PIX DATA STRB(+)	63	PIX DATA STRB(-)	Camera
30	EXPOSE(+)	64	EXPOSE(-)	User
31	AMSB-9 (+)	65	AMSB-9 (-)	Camera
32	BMSB-8 (+)	66	BMSB-8 (-)	Camera
33	BMSB-9 (+)	67	BMSB-9 (-)	Camera
34	GROUND	68	GROUND	Both

PIN	SIGNAL NAME	PIN	SIGNAL NAME
1	Open	6	Open
2	Transmit(TX) from camera	7	Connected to pin 8
3	Receive(RX) from user	8	Connected to pin 7
4	Open	9	Open
5	Ground		

(* - Illustrated on page 2-3)

Table 4-3. 26-Pin Camera Link Cable Pinout

PIN	SIGNAL NAME	PIN	SIGNAL NAME	SOURCE
1	IN SHLD GND	14	IN SHLD GND	Both
2	X0 (-)	15	X0 (+)	Camera
3	X1 (-)	16	X1 (+)	Camera
4	X2 (-)	17	X2 (+)	Camera
5	XCLK (-)	18	XCLK (+)	Camera
6	X3 (-)	19	X3 (+)	Camera
7	SER CNTL IN (+)	20	SER CNTL IN (-)	Camera
8	SER CNTL OUT (-)	21	SER CNTL OUT (+)	Camera
9	EXPOSE (-)	22	EXPOSE (+)	Camera
10	SPARE IN (-)	23	SPARE IN (+)	Camera
11	NOT USED*	24	NOT USED*	
12	NOT USED*	25	NOT USED*	
13	IN SHLD GND	26	IN SHLD GND	Both

*(Terminated)

4.7 Timing Waveforms

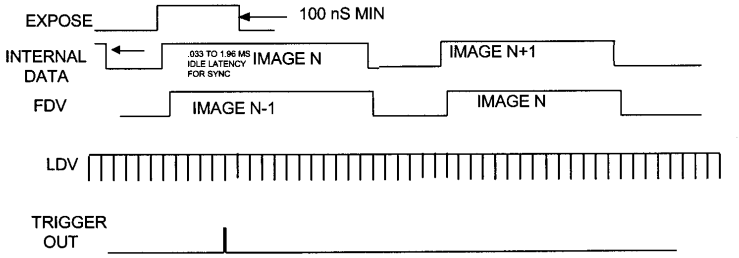

Figure 4-2. Continuous Mode – Variable Exposure Timing

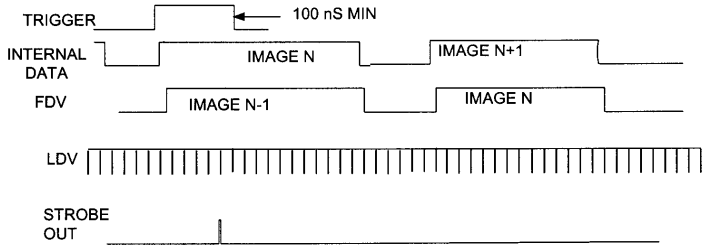

Figure 4-3. Continuous Mode – Variable Exposure Timing (With External Trigger Sync)

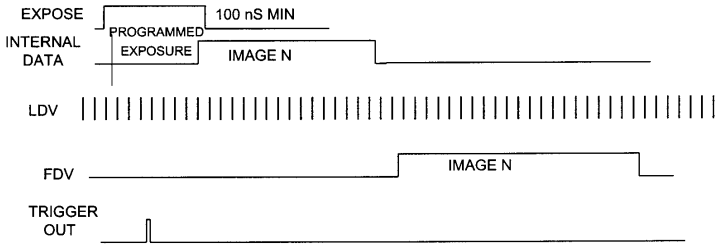

Figure 4-4. Triggered Mode Timing

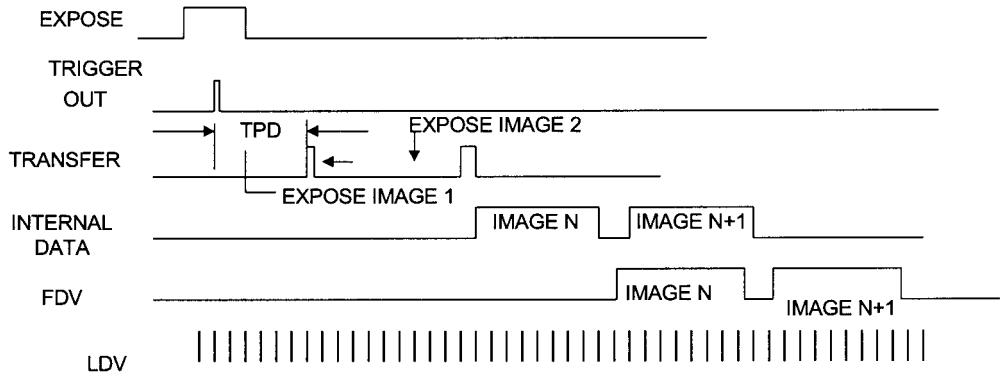

Figure 4-6. Double Image Mode Timing

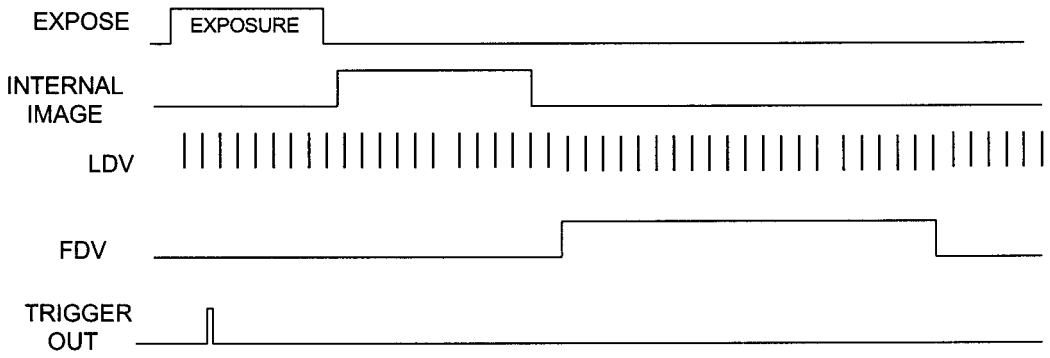

Figure 4-7. Controlled Mode Timing

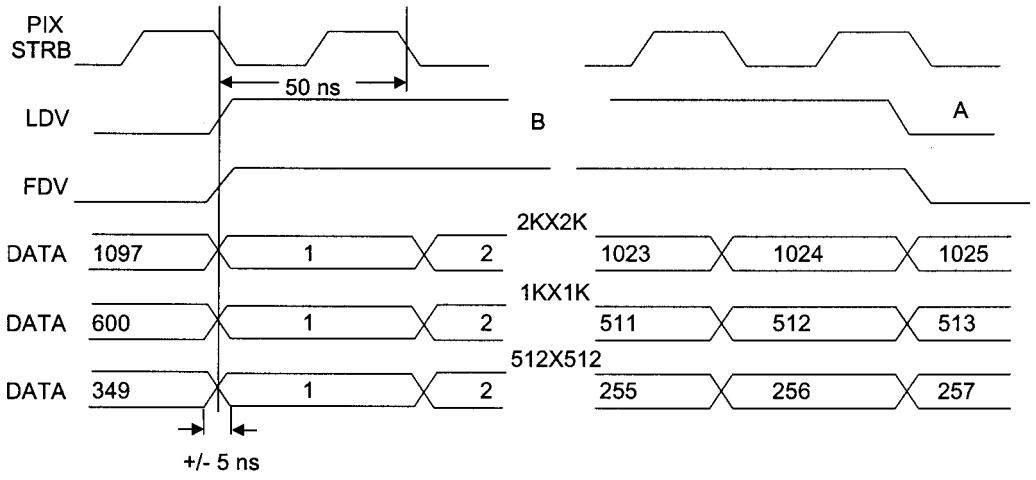

Figure 4-8. Line Timing

4.8 Specifications

4.8.1 Video Performance

Black Level:	Clamped to black reference at the start of each frame.
Gamma:	Unity.
Scanning:	Non-Interlaced, progressive.
Synchronization:	Pixel clock internal.
Dynamic Range:	>62 dB 12-bit, no binning at 2K x 2K 48 dB 8-bit, no binning at 2K x 2K.
Antibloom:	100 times at 66-millisecond exposure.
Pixel Clock Rate:	10 MHz, 20 MHz, 40 MHz.
Max. Frame Rate:	15 fps maximum (2Kx2K mode) 30 fps maximum (1Kx1K mode) 60 fps maximum (512x512 mode)

4.8.2 Camera Mechanical

Housing:	Extruded aluminum case.
Dimensions:	4.30” H x 4.30” W x 6.67” L (109.2 x 109.2 x 169.3mm).
Lens:	C-Mount or F-Mount.
Weight:	Approximately 4 pounds (1.8 Kg).
Mount:	Two ¼ - 20 threaded holes with locating pin holes.
Vibration:	3G, sinusoidal from 5 to 150 Hz.
Shock:	20G (nonoperating).

4.8.3 Temperature

Operating:	0 to 40°C (32 to 104°F), non-condensing (Image quality will degrade with increasing temperature)
Storage:	-25 to +70°C (-13 to 158°F), non-condensing.

4.8.4 Humidity

Operating:	<80% @ 40°C (104°F).
Storage:	<40% @ 70°C (158°F).

4.9 C-Mount Camera Dimensions

NOTE: Dimensions contained in brackets, [xx.x], are in millimeters. Other dimensions are in inches.

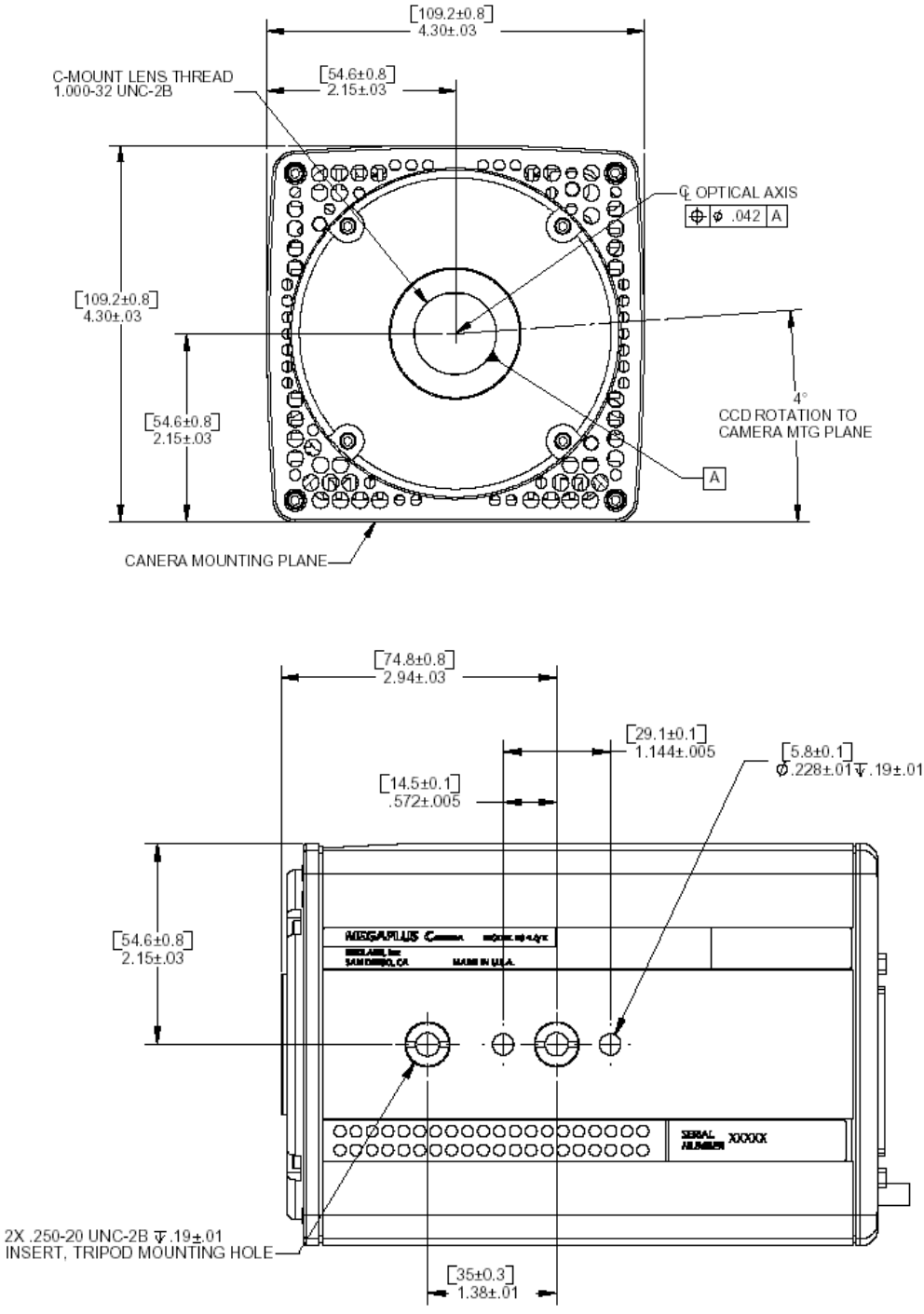

Figure 4-9. C-Mount Camera Dimensions (Front and Bottom Views)

NOTE: Dimensions contained in brackets, [xx.x], are in millimeters. Other dimensions are in inches.

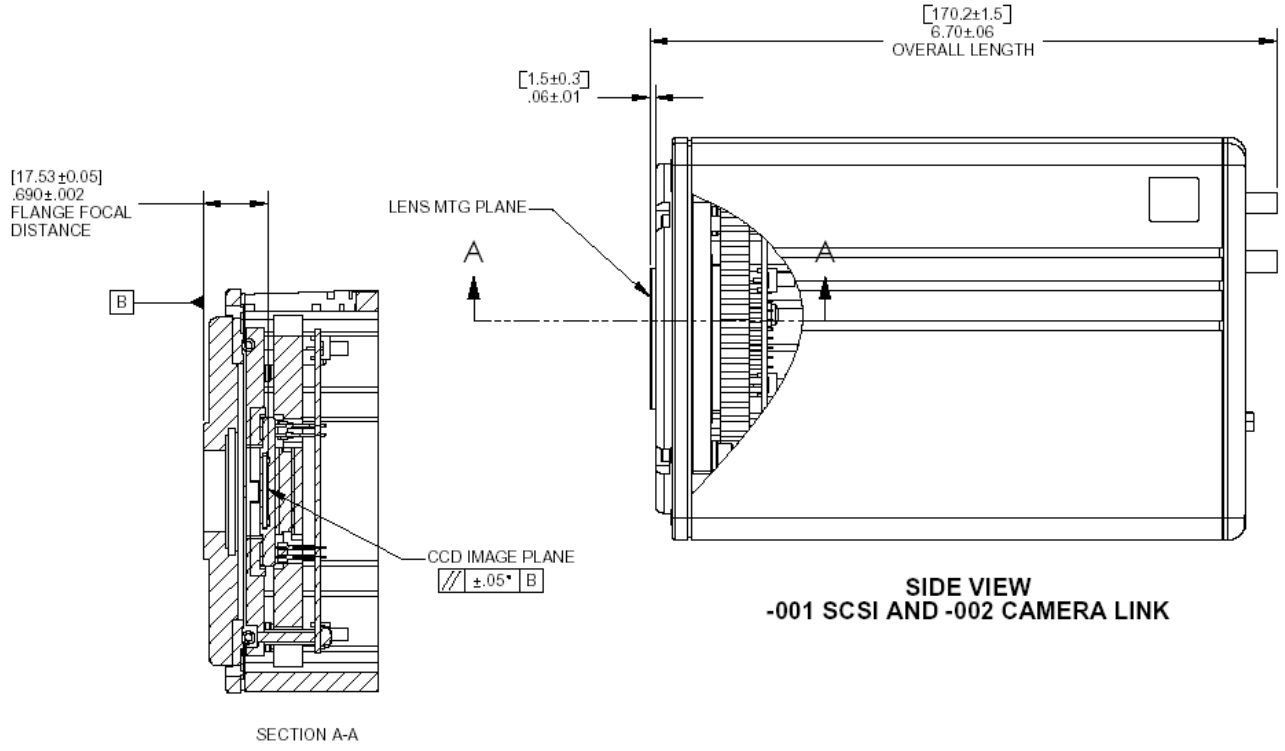

Figure 4-10. C-Mount Camera Dimensions (Side View)

4.10 F-Mount Camera Dimensions

NOTE: Dimensions contained in brackets, [xx.x], are in millimeters. Other dimensions are in inches.

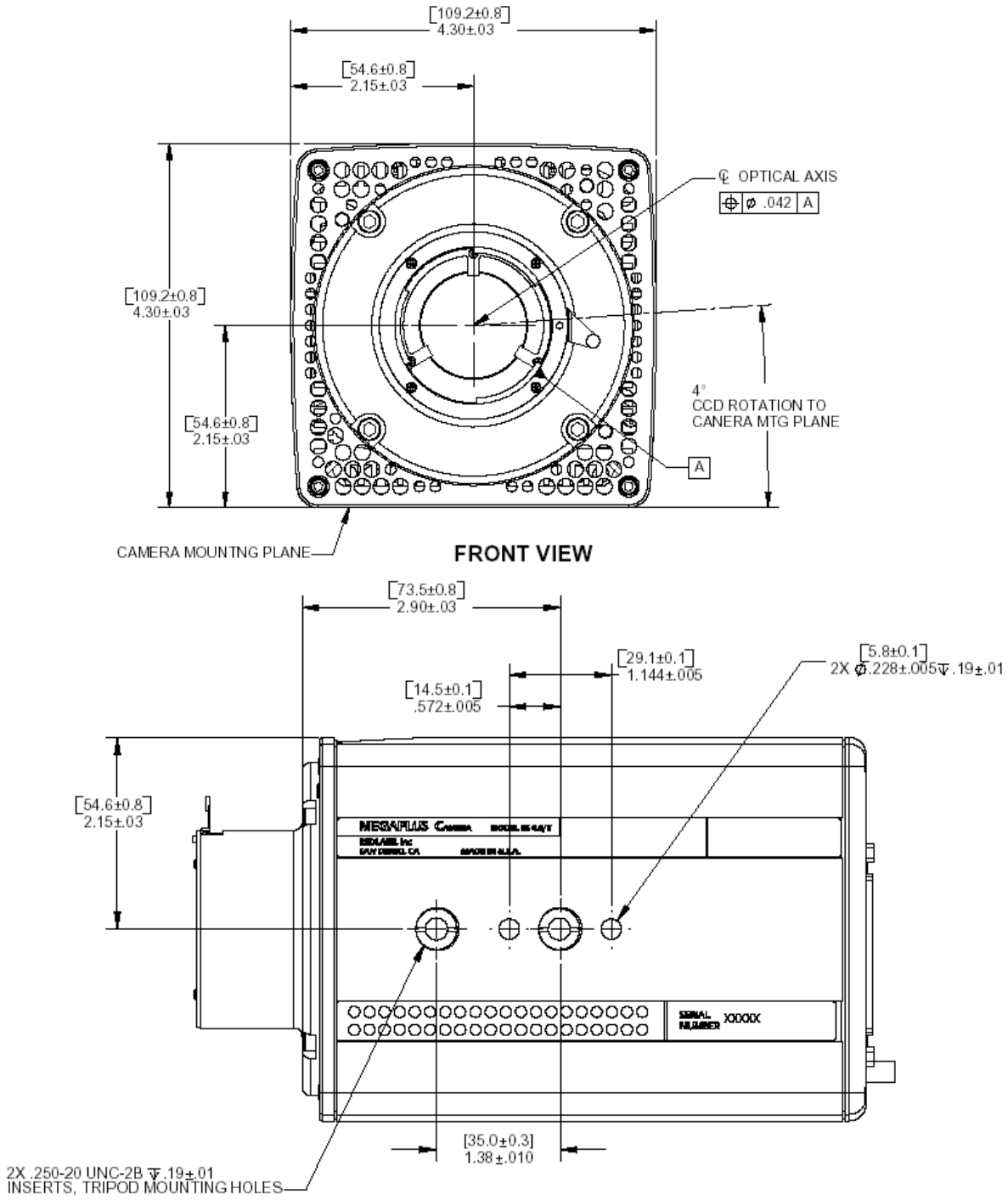

Figure 4-11. F-Mount Camera Dimensions (Front and Bottom Views)

NOTE: Dimensions contained in brackets, [xx.x], are in millimeters. Other dimensions are in inches.

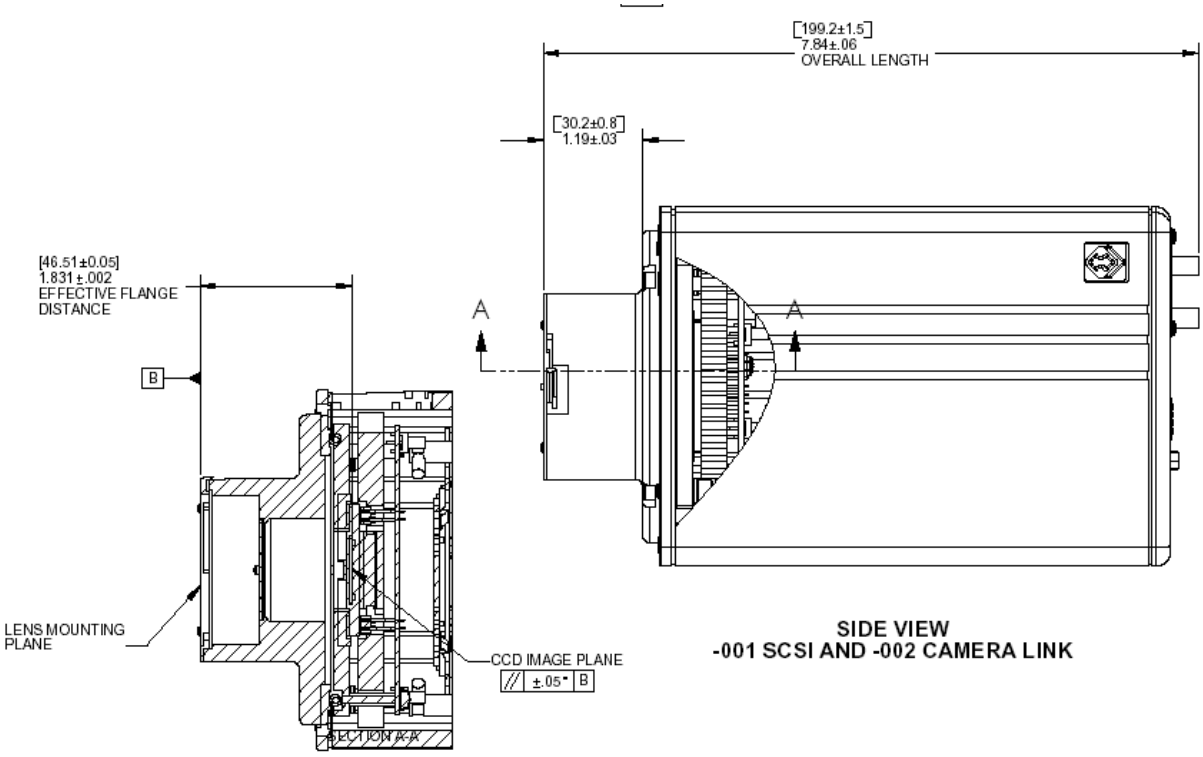

Figure 4-12. F-Mount Camera Dimensions (Side View)

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX A – ERROR CODES AND DESCRIPTIONS

Code	Name	Description
	ERROR_NONE	
01	ERROR_SYNTAX	Bad command
02	ERROR_XMIT	UART error
03	ERROR_ARGUMENT	Data out of range
04	ERROR_TYPE	Data not type requested
05	ERROR_UNTERMINATED	String not NULL terminated
06	ERROR_INDEX	Can not INC or DEC command
07	ERROR_SPI	SPI transmitting/receiving problem
08	ERROR_STATE	Attempting to set camera to illegal state
09	ERROR_FLASH	Flash read/write problem
10	ERROR_CATS	CaTS send/receive problem
11	ERROR_DAYTONA	DAYTONA command only
12	ERROR_CSUM	Checksum error
13		Not Used
14		Not Used
15	ERROR_TEMP	Camera temperature out of range
16	ERROR_SENS_TEC	TEC out of range
17	ERROR_SENS_FAN	Fan failure
18		Not Used
19	ERROR_P45	+45 volts failure
20	ERROR_P15	+15 volts failure
21	ERROR_P10	+10 volts failure
22	ERROR_P8	+8 volts failure
23	ERROR_P5	+5 volts failure
24	ERROR_N5	-5 volts failure
25	ERROR_N12	-12 volts failure
26	ERROR_FLASH_ACCESS	Flash access denied
27	ERROR_FLASH_ERASE	Flash erase operation failed
28	ERROR_FLASH_WRITE	Flash write operation failed
29	ERROR_FLASH_READ	Flash read operation failed
30	ERROR_FRBUFF_CONFIG_INIT	Configuration initialization problem
31	ERROR_FRBUFF_CONFIG_TIMEOUT	Configuration register problem
32	ERROR_FRBUFF_CONFIG	Configuration data problem
33	ERROR_FRBUFF_CONFIG_DONE	Configuration did not finish properly
34	ERROR_ANALOG_CONFIG_INIT	Configuration initialization problem
35	ERROR_ANALOG_CONFIG_TIMEOUT	Configuration register problem
36	ERROR_ANALOG1_CONFIG	Configuration data problem
37	ERROR_ANALOG2_CONFIG	Configuration data problem
38	ERROR_ANALOG_CONFIG_DONE	Configuration did not finish properly
41	ERROR_PASSWORDS	Password table did not load
42	WARNING_FAS	Fast readout turned off
99	DOWNLOAD_OPERATION_OK	For file download handshaking

THIS PAGE INTENTIONALLY LEFT BLANK